

**The claims:**

1. Apparatus for monitoring an electrical power supply system of a vehicle,  
the vehicle having a battery and internal combustion engine, an alternator,  
and a starter; the apparatus comprising:
  - (a) a filter for determining the battery terminal voltage when the  
vehicle ignition is turned on;
  - (b) a voltage gradient detector for detecting phase and gradient  
change of the battery terminal voltage when the vehicle ignition is  
on;
  - (c) a waveform detector for detecting and separating different  
waveforms when the vehicle ignition is on;
  - (d) an engine-rotating sensor for sensing a speed of the internal  
combustion engine when the vehicle ignition is on;
  - (e) a processor for processing at least one of the battery terminal  
voltage, the phase and gradient change, the different waveforms,  
and the speed of the internal combustion engine for providing an  
output indicative of a condition of the electrical power supply  
system.
2. Apparatus as claimed in claim 1, further including an output controller for  
decoding data from the processor to control at least one device.
3. Apparatus as claimed in claim 2, wherein the at least one device includes  
one or more selected from the group consisting of a digital-to-analogue  
converter, a character generator for driving an LCD, a tone generator for  
driving a speaker, an LED colour pattern generator for driving a colour  
LED, an infrared printing interface for driving an infrared transmitter, and a  
computer link interface for coupling to an output port when the vehicle  
ignition is on.
4. Apparatus as claimed in any one of claims 1 to 3, further including a  
temperature sensor for detecting ambient temperature.
5. A system for monitoring an electrical power supply system of a vehicle,  
the vehicle having a battery, an internal combustion engine, an alternator  
and a starter, the system including:

- 5 (a) determining the battery terminal voltage when the vehicle ignition is on;
- (b) detecting phase and gradient change of the battery terminal voltage when the vehicle ignition is on;
- 10 (c) detecting and separating different waveforms when the vehicle ignition is on;
- (d) sensing a speed of the internal combustion engine when the vehicle ignition is on;
- (e) processing at least one of the battery terminal voltage, the phase and gradient change, the different waveforms, and the engine speed; and
- (f) providing an output indicative of the condition of the electrical power supply system.
- 15 6. A system as claimed in claim 5, including determining a status of the internal combustion engine, the status being selected from the group consisting of: not running, cranking, running, and normal.
- 20 7. A system as claimed in claim 6, wherein the status is not running if there is satisfaction of one or more selected from the group consisting of:
- (a) the battery terminal voltage when the vehicle ignition is on is less than the battery terminal voltage when the ignition is off;
- (b) the gradient change is in a range from less than zero to zero;
- (c) a ripple waveform is zero; and
- 25 (d) the speed of the internal combustion engine is zero.
8. A system as claimed in claim 6 or claim 7, wherein the status is cranking if there is satisfaction of one or more selected from the group consisting of:
- 30 (a) the gradient of the battery terminal voltage is lower than a predetermined value;
- (b) the battery terminal voltage with the ignition on is at a predetermined value below of the battery terminal voltage with the ignition off; and
- (c) the speed of the internal combustion engine is zero.
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9. A system as claimed in any one of claims 6 to 8, wherein a time duration for the starter cranking the internal combustion engine is determined by one or more of:
- (a) determining the time duration between the gradient change of the battery terminal voltage changing from a significant figure when negative to the significant figure when positive;
  - (b) the time duration before and after battery voltage gradient changes;
  - (c) the terminal voltage being constant, and
  - (d) the speed of the internal combustion engine moves from zero to a positive figure.
10. A system as claimed in claim 9, wherein if the time duration exceeds a predetermined time, the internal combustion engine will have a poor cranking ability.
11. A system as claimed in claim 10, wherein if, after the predetermined time, the speed of the internal combustion engine is above a pre-set minimum the engine status is running.
12. A system as claimed in any one of claims 7 to 11, wherein if the ripple waveform is greater than zero, the engine status is running.
13. A system as claimed in claim 10, wherein if after the predetermined time the speed of the internal combustion engine is zero, the engine status is that cranking failed.
14. A system as claimed in any one of claims 7 to 12, wherein an alternator status is determined from the internal combination engine status and the ripple waveform.
15. A system as claimed in claim 14, wherein if the engine status is running, and the ripple waveform is zero, the alternator status is malfunction.
16. A system as claimed in any one of claims 5 to 15, a determination of remaining electrical energy operating time of the battery is made from a consideration of the battery terminal voltage, voltage gradient, the gradient change, and a predetermined end of discharge voltage.

17. A system as claimed in claim 16 wherein the determination is taken on a regular periodic basis.
- 5 18. A system as claimed in claims 7 to 17 wherein if the engine speed is above the pre-set minimum, a ripple factor is below a predetermined maximum, and the battery terminal voltage within an acceptable range, the internal combustion engine status is normal.
- 10 19. A system as claimed in claim 18 wherein a status of the battery is determined from a consideration of engine speed being above the pre-set minimum, the ripple factor being lower than the predetermined maximum, and the battery terminal voltage being within the acceptable range.
- 15 20. A system as claimed in any one of claims 7 to 19, wherein the status of the alternator is determined from a consideration of an ignition pulse frequency, the ripple waveform, the battery terminal voltage, and the speed of the internal combustion engine.
- 20 21. A system as claimed in any one of claims 18 to 20, wherein a battery charge status is determined from a consideration of the ripple factor and the battery terminal voltage.
- 25 22. A system as claimed in claim 21, wherein upon the battery being degraded, the ripple factor is greater than the predetermined maximum and the battery terminal voltage is within the required voltage range.
- 30 23. A system as claimed in claims 21 or claim 22, wherein the ripple factor is used to determine a battery impedance status.
- 35 24. A system as claimed in any one of claims 5 to 12, wherein a ratio of a speed of the alternator to the speed of the internal combustion engine is used to determine the status of an alternator drive belt.
25. A system as claimed in claim 24, wherein the ratio is compared to a highest recorded ratio.

26. A system as claimed in claim 25 wherein the comparison is below a minimum figure, the alternator is faulty as one phase is not working.
- 5 27. A system as claimed in any one of claims 14 to 26, wherein the alternator is undersized if the battery terminal voltage is below a predetermined minimum voltage, the engine speed is above the pre-set minimum, the ripple factor is below the predetermined maximum, and the alternator rotation is within an acceptable range.
- 10 28. A system as claimed in any one of claims 14 to 27, wherein the alternator is faulty if the battery terminal voltage is above a predetermined maximum voltage, the engine speed is above the pre-set minimum, the ripple factor is below the predetermined maximum, and the alternator rotation is within an acceptable range.
- 15 29. A system as claimed in any one of claims 14 to 28, wherein the battery is undersized if the discharge voltage gradient is below a predetermined level, the battery terminal voltage is between a predetermined maximum voltage and a predetermined minimum voltage, the engine speed is above the pre-set minimum, the ripple factor is below the predetermined maximum, and the alternator rotation is within an acceptable range.
- 20 30. A system as claimed in any one of claims 5 to 29, wherein to determine a cranking circuit quality before an armature rotates, the ratio of the highest recorded beginning cranking voltage gradient to the beginning cranking voltage gradient is recorded as a percentage to show the cranking circuit quality.
- 25 31. A system as claimed in claim 30, wherein the condition of the cranking circuit quality is determined by at least one selected from the group consisting of: the starter condition, the condition of the starter brushes, battery terminal connection, battery cable connection, battery condition, battery electrolyte condition, and battery impedance.
- 30 32. A system as claimed in any one of claims 30 to 31, wherein the cranking circuit quality is unacceptable when the cranking circuit quality is less than the predetermined minimum required cranking circuit quality.
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33. A system as claimed in any one of claims 5 to 32, wherein a static cranking torque capability of the internal combustion engine is determined by use of:  
a cranking voltage ratio of the lowest valley voltage to a voltage at  
maximum power transfer before an armature rotates, converting the  
voltage ratio to a current ratio, and recording the current ratio as a  
percentage for the static cranking torque capability of the internal  
combustion engine.
34. A system as claimed in claim 33, wherein a determination of the static cranking torque capability is made by at least one of the group consisting of: if the battery is undersized when the cranking circuit quality is acceptable and the static cranking torque capability is below an acceptable limit, if the starter is unacceptable when the static cranking torque capability is below the acceptable limit, if the battery condition is unacceptable when the static cranking torque capability is below the acceptable limit, if the battery terminal is poorly contacted when the static cranking torque capability is below the acceptable limit, and if the battery cable is poorly contacted when the static cranking torque capability is below the acceptable limit.
35. A system as claimed in any one of claims 33 to 34, wherein upon the cranking torque capability becoming unacceptable the cranking torque capability is less than the predetermined minimum required cranking torque capability.
36. A system as claimed in any one of claims 5 to 29, wherein a cranking power capability is determinable by converting a cranking voltage from when an armature commences rotating to an end of cranking to a voltage equivalent of the armature back emf; determining an emf ratio of armature back emf and a maximum power transfer armature back emf converting the emf ratio to a corresponding power ratio; record the corresponding power ration as a percentage to show the cranking power capability.
37. A system as claimed in any one of claims 5 to 29, wherein a cranking power capability is determined by computing the ratio of the cranking battery terminal voltage from when the starter armature commences

rotating, to an end of cranking, to a maximum cranking power battery terminal voltage; converting the ratio to a corresponding power ratio, and expressing the corresponding power ratio as a percentage to show the cranking power capability.

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38. A system as claimed in claim 36 or claim 37, wherein the cranking power capability is used to determine the presence of at least one of:

- (a) starter is malfunctioning when the cranking circuit quality and cranking torque capability are within their respective pre-set limits,
- 10 (b) the battery is undersized when the cranking circuit quality is within limits,
- (c) the battery terminal is poorly contacted,
- (d) the battery cable poorly is contacted, and
- (e) the battery condition is unacceptable

15 when the cranking power capability is below a predetermined minimum required cranking power capability.

39. A system as claimed in any one of claims 36 to 38, wherein the cranking power capability is unacceptable when the cranking power capability is less than the predetermined minimum required cranking power capability.

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40. A system as claimed in any one of claims 5 to 39, wherein the output is at least one full-colour LED the colour of which is modulated by a plurality of primary colours in an illumination duty cycle according to a voltage ratio of battery terminal voltage under load to no-load, the colour of the LED corresponding the voltage of the battery.

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41. A system as claimed in claim 40, wherein the LED colour is dependent upon the battery terminal voltage.

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42. A system as claimed in claim 41, wherein the LED colour is dependent upon the battery charge status.

43. A system as claimed in any one of claims 40 to 42, wherein the LED acts as a colour-voltmeter.

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- 5 44. A system as claimed in any one of claims 40 to 43, wherein the at least one LED is used to provide the output for one or more selected from the group consisting of: cranking power capability, cranking torque capability, status of the battery, alternator status, and cranking circuit quality.
- 10 45. A system as claimed in claim 44, wherein upon it being determined that the alternator and battery are in good condition, the LED is reduced to an intensity as a percentage of full intensity, the percentage being in a range from of 0% to 75%.
- 15 46. A system as claimed in any one of claims 5 to 45, wherein the output is an audio generator.
- 20 47. A system as claimed in claim 46, wherein the audio generator is used to output an audio signal depending on the quality of one or more selected from the group consisting of: the initial condition, low battery charge, battery over charge, low cranking circuit quality, low cranking power capability, low cranking torque capability, at least one battery cell damaged, and alternator malfunction.
- 25 48. A system as claimed in claim 47, wherein the audio signal is varied according to one or more selected from the group consisting of: frequency, number of tones, duty cycle, base frequency, and string.
49. A computer usable medium comprising a computer program code that is configured to cause at least one processor to execute one or more functions to perform the steps of any one of claims 5 to 48.